

Vulpes macrotis. By John C. McGrew

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Vulpes macrotis Merriam, 1888

Kit Fox

Vulpes macrotis Merriam, 1888:136. Type locality "Riverside, San Bernardino County, California." More exactly, on the western margin of the San Jacinto Plain in the vicinity of Box Springs, within 10 miles southeast of Riverside. This locality is clearly in Riverside County, not San Bernardino (Miller and Kellogg, 1955:685; Hall and Kelson, 1959:858).

Vulpes muticus Merriam, 1902:74. Type locality Tracy, San Joaquin County, California.

Vulpes arsipus Elliot, 1903:256. Type locality Daggett, Mohave Desert, San Bernardino County, California.

CONTEXT AND CONTENT. Order Carnivora, Family Canidae, Subfamily Caninae, Genus *Vulpes*, in which there are 10 to 13 species, depending on the authority accepted. Eight subspecies of *V. macrotis* are currently recognized (Miller and Kellogg, 1955:685):

V. m. macrotis Merriam, 1888:136, see above.

V. m. mutica Merriam, 1902:74, see above (spelling changed by Grinnell, 1933).

V. m. neomexicana Merriam, 1902:74. Type locality Baird's Ranch, eastern side of San Andres Mountains, Dona Ana County, New Mexico (about 50 mi N El Paso, Texas—see Halloran, 1945:93).

V. m. arsipus Elliot, 1903:256, see above (*arizonensis* Goldman is a synonym).

V. m. devia Nelson and Goldman, 1909:25. Type locality Llano de Yrais, opposite Magdalena Island, Baja California, Mexico (spelling changed from *devius* by Miller and Kellogg, 1955).

V. m. nevadensis Goldman, 1931:250. Type locality Willow Creek Ranch, near Jungo, Humboldt County, Nevada.

V. m. tenuirostris Nelson and Goldman, 1931:302. Type locality Trinidad Valley, northwest base of Sierra San Pedro Martir, Baja California, Mexico. Altitude 2,600 feet.

V. m. zinseri Benson, 1938:21. Type locality San Antonio de Jaral, southeastern Coahuila, Mexico.

DIAGNOSIS. *Vulpes macrotis* can be differentiated from other North American foxes by a number of criteria. Compared with the red fox (*V. vulpes*), the kit fox is always smaller, with most linear measurements averaging about 25% less than comparable measurements of the red fox (Hall, 1946). The legs and feet of *V. macrotis* are whitish or about the same color as the body, and the tail is black-tipped (figure 1); red foxes have black legs and feet and a white-tipped tail. Kit foxes lack the prominent band of coarse black hairs (the "mane" of Seton, 1923) which runs dorsally down the tail of the gray fox (*Urocyon cinereoargenteus*), and the tail of the gray fox is somewhat triangular in cross section while the tail of *V. macrotis* is round.

Vulpes macrotis closely resembles *V. velox* in appearance and habits. The two forms may be separated by the following external characteristics (Armstrong, 1972; Thornton and Creel, 1975): 1) ears >75 mm from the notch in *macrotis*, <75 mm in *velox*; 2) ear bases set close to the midline of the skull in *macrotis*, widely spaced in *velox* (a frontal-view sketch of the two forms is provided by Thornton and Creel, 1975); 3) the head of *macrotis* is comparatively broader between the eyes and narrower in the snout than that of *velox*. The eyes of *macrotis* are described by Thornton and Creel (1975) as characteristically slit-like, *velox* eyes being more open and rounded. However, this trait varies with individuals in the red fox and may not be reliable in this case either. In a sample of five *macrotis* and eight *velox*, the tail of *macrotis* was significantly longer, averaging 62% of body length compared with 52% in *velox* (Thornton and Creel, 1975:131).

Kit foxes superficially resemble a number of Old World desert foxes, which have large ears, small bodies, and light pelage color. The corsac fox (*Vulpes corsac*), found in the steppes and

deserts of Central Asia, is about the same size as *V. macrotis* with long, slender legs and long ears. Its coat is a reddish-gray or reddish-brown, and the tip of the tail is weakly brown or black. Ruppell's fox (*V. ruppelli*), which is widely distributed in North Africa and the Near East, is slightly smaller than *V. corsac*, with a reddish-gray agouti coat and a reddish-orange stripe extending from the back of the neck to the tail. The tail is white-tipped. Ruppell's fox has a 2N number of 40 (Chiarelli, 1975). The pale sand fox (*V. pallida*) of subsaharan Africa has thin, short, sandy-colored fur. The ears are smaller proportionately than those of other desert foxes, and are rounded at the tips (Bueler, 1973). The 2N number is 38 (Chiarelli, 1975). *Vulpes chama*, the Cape fox, and *Fennecus zerda*, the fennec, can be distinguished from *V. macrotis* by size. The Cape fox, found in southern and southwestern Africa, is rather large, weighing 3.5 to 4.5 kg and measuring as much as one meter in total length. The back is silvery in color, and the tip of the tail is black. The fennec is the smallest species of the Canidae, standing only about 200 mm at the shoulder and weighing about 1.4 kg. The ears are enormous, very broad at the base and measuring 100 to 150 mm in length. The pelage is pale and the tail is black-tipped. The cranium is broad and smooth, the dentition weak, and the bullae exceedingly large and inflated (Bueler, 1973; Clutton-Brock *et al.*, 1976). Fennecs have a 2N number of 64 (Chiarelli, 1975).

GENERAL CHARACTERS. Kit foxes have a typical vulpine appearance. The body is slim; the ears are relatively much larger than those of any other North American canid; and the tail is long (about 40% of total length), bushy, and tapers slightly toward the tip. The legs are long and slender, and the soles of the feet are well haired. Grinnell *et al.* (1937) suggested that the long hair on the feet improves traction on sandy surfaces. The skull is narrow and delicate with a long, slender rostrum. The tympanic bullae are well inflated. There is no pronounced sagittal crest (figures 2 and 3), although mature individuals of *V. m. mutica* have a small crest (Waithman and Roest, 1977).

Color and texture of the pelage vary geographically. In general, dorsal coloration is a light grizzled- or yellowish-gray. The grizzled appearance results from guard hairs which are typically black-tipped or with two bands of black separated by a band of white. Guard hairs are less than 50 mm long (Mayer, 1952) and especially prominent on the middle of the back. The underfur is heavy and slightly harsh in texture. Dorsally this fur is gray at the base, becoming paler on the sides, and light buff to white on the underparts (Grinnell *et al.*, 1937). The ears are tan or gray on the back, changing to buff or orange at the base. The pinnae have a thick border of white hairs on the forward inner edge and inner base. The sides of the muzzle, the lower lip and the pos-



FIGURE 1. A young *V. m. nevadensis* at a den near Deseret, Millard Co., Utah. Photo by the author.

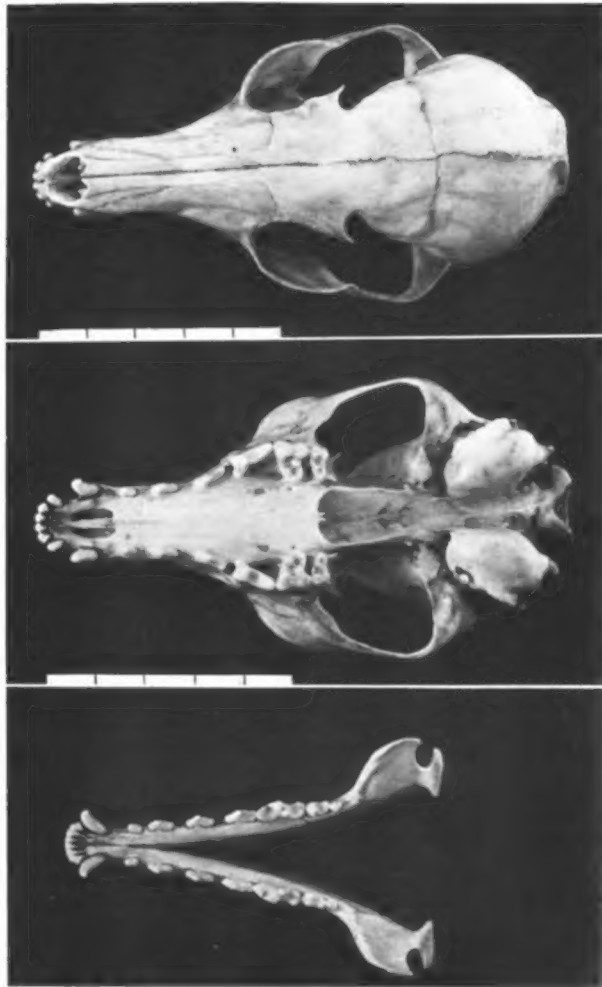


FIGURE 2. Dorsal and ventral views of cranium, and occlusal view of mandible, of *V. m. arsipus* from Washington County, Utah. Specimen No. 2 from the author's collection. Photos by the author. Scales represent 50 mm.

terior one-third of the upper lip, and all vibrissae are blackish or brownish. The shoulders, lower sides, flanks, and a strip about 25 mm wide across the chest range in color from buffy to orange. The venter is white. The tail is about 60 to 76 mm in diameter and is gray except for the proximal half of the lower surface, which is buffy. The black tip of the tail and prominent black spot marking the location of the supracaudal gland are due to an increasing amount of black-tipping on the long guard hairs.

Secondary sexual variation in size is not marked, but males are considerably heavier than females. In a series of 10 males and nine females of *V. m. mutica* reported by Grinnell *et al.* (1937), females averaged only three to four percent smaller in all external measurements, but nearly 15 percent lighter in weight (see below). There is no clear sexual dimorphism in cranial or skeletal characteristics (Hildebrand, 1952a; Waithman and Roest, 1977). External measurements (mean and range in mm) for 19 *V. m. mutica* are as follows (Grinnell *et al.*, 1937): total length, 788 (730 to 840); length of tail, 290 (260 to 323); length of hind foot, 122 (113 to 137); length of ear, 85 (78 to 94). Males ($N = 10$) averaged about 2.2 kg while 9 females averaged almost 1.9 kg. Selected cranial measurements (mean and standard deviation) from 35 *V. m. mutica* specimens are as follows (Waithman and Roest, 1977): condylobasal length, 114.4 (4.05); zygomatic breadth, 62.1 (2.23); palatal length, 57.8 (2.39); rostral breadth at canines, 18.0 (0.77); rostral breadth at M1, 33.0 (1.22); interorbital breadth, 23.1 (1.13); postorbital breadth, 21.4 (1.34). For additional measurements see Nelson and Goldman (1931), Benson (1938), and Hall (1946).

The original descriptions of the several subspecies were based on small numbers of specimens and generally consisted of



FIGURE 3. Lateral view of skull of same specimen shown in Figure 2. Scale represents 50 mm.

qualitative differences in skull shape or variations in pelage color. Benson (1938) synonymized *V. m. arizonensis* under *V. m. arsipus* when a large sample of skulls and pelts from Arizona and California failed to reveal any consistent differences between the two groups. Stepwise discriminant analysis of cranial characteristics of *V. m. arsipus*, *devia*, *tenuirostris*, and *macrotis* suggested that differences between them are slight and probably clinal in nature (Waithman and Roest, 1977). On the basis of these findings and because of similarities in habitat preference, the authors recommended that the four subspecies be synonymized under *V. m. macrotis* (see Remarks). Other workers (Grinnell *et al.*, 1937; Benson, 1938; Hall, 1946) suggested that *V. m. arsipus* and *V. m. nevadensis* were not sufficiently different to warrant recognition of two distinct subspecies, but discriminant analysis of 24 *nevadensis* and 16 *arsipus* skulls from Utah showed a significant difference between the two groups (McGrew, 1977).

DISTRIBUTION. The distribution of *V. macrotis* is closely associated with desert and semi-arid regions of western North America (figure 4). Historically kit foxes probably were found throughout the Sonora, Chihuahua, Mohave, and Painted deserts and much of the Great Basin Desert (see Jaeger, 1957). Current distribution is incompletely known (except perhaps for *V. m. mutica*). *V. m. macrotis* formerly occurred from Riverside County northwestward to Los Angeles County, California, but was extirpated from those areas by 1910 (Grinnell *et al.*, 1937). The range of *mutica* is much reduced from historical accounts (Laughlin, 1970; Jensen, 1972; Morrell, 1975), and the subspecies is currently listed as Endangered by the U.S. Department of Interior (1976). *V. m. arsipus* is found in the Mohave Desert of California, southern Nevada, and extreme southwestern Utah; and in the Sonora Desert of Arizona. *V. m. nevadensis* is common in Nevada and in western Utah, but its present status in the northern Great Basin is unknown. It is listed as Endangered by the state of Oregon (Olterman and Verts, 1972), but Laughlin and Cooper (1973) recently reported a range extension in Klamath County, Oregon. McGrew (1977) documented a range extension of about 12,000 km² in eastern Utah, based on specimens and numerous sightings from that area. Findley *et al.* (1975) reviewed the distribution of *neomexicana* in New Mexico. Distribution of the Mexican subspecies is virtually unknown; *V. m. devia* and *V. m. tenuirostris* are known only from their type localities in Baja California. Baker (1956) and Anderson and Hadary (1965) have published marginal records for *V. m. zinseri* from southwestern Coahuila and Zacatecas, respectively.

FOSSIL RECORD. The fossil record of *V. macrotis* is very scanty. Bones of kit foxes have been found in three Great Basin archaeological sites: Juke Box Cave near Wendover, Utah (Jennings, 1957); Hogup Cave in northwestern Utah (Aikens, 1970); and the Dirty Shame Rockshelter in the southeastern corner of Oregon (Grayson, 1977). All three sites are late Pleistocene or early Holocene (circa 6,500–10,000 YBP). Gilmore (1947) listed two bone fragments of undetermined age from a cave in the Mexican state of Coahuila.

FORM. Superciliary, ventral genal, and interramal vibrissae are about the same length in wolves, coyotes, and foxes, but the length of the mystacial vibrissae varies inversely with body size, suggesting that these vibrissae are more useful to the foxes than the wolf (Hildebrand, 1952b). Carpal vibrissae are often longer on the kit fox than on coyotes and wolves (Hildebrand, 1952b). Normally there are 8 mammae (Hildebrand, 1952b).

Despite their reputation for speed, kit foxes have relatively

shorter legs and feet than do red foxes (Hildebrand, 1952a). This is probably not a function of body size, and may represent a reduced capability for speed (Hildebrand, 1954). The calcanea of *V. macrotis* are smaller than any recorded for the genus *Canis* and are the smallest of the genus *Vulpes* except for some overlap with *V. velox* (Stains, 1975). Calcanea of *V. macrotis* are generally greater in total length, wider, and shorter in dorsal-ventral height than those of *V. velox*.

There are 42 teeth (i 3/3, c 1/1, p 4/4, m 2/3).

FUNCTION. Kit foxes are almost exclusively carnivorous and apparently obtain adequate moisture from their prey, since they often den many kilometers from water (Egoscue, 1962; Morrell, 1972; McGrew, 1977). They are largely nocturnal and avoid heat stress during the day by remaining inactive in underground dens. Unlike many canids which pant only at the resonant frequency of the thorax, kit foxes pant at a rate proportionate to the ambient temperature until the rate reaches resonant frequency (maximum noted: 576 cycles/minute). In doing so, kit foxes practice water economy at the expense of energy (Denver Wildlife Research Center, 1975). Urine concentration has not been reported for the kit fox; feces are very dry.

The apparent speed of kit foxes is largely an illusion created by their small size and cryptic coloration, and by their remarkable ability to dodge and change directions. One reliable account clocked a kit fox at about 40 km/h in front of a car, but the fox tired rapidly and soon began to run erratically (Grinnell *et al.*, 1937).

ONTOGENY AND REPRODUCTION. Vixens begin searching for natal dens in September and October. Often every usable den within the home range of the vixen is visited and cleaned of debris before the final selection is made. No nest as such is built, but new entrances and tunnels may be added to the den (Egoscue, 1956, 1962; Morrell, 1972). Natal dens are usually separated by at least 3.2 km (Egoscue, 1956, 1962). Males join the females at the natal dens in October or November, and breeding occurs from December to January or February. Kit foxes are monestrous. Nothing is known of courtship behavior. As with most canids, copulation ends with a "tie" during which the penis is locked in the female's vagina (Egoscue, 1956).

Kit foxes are often said to be monogamous and to mate for life (Grinnell *et al.*, 1937; Egoscue, 1962). However, only one of seven kit fox pairs observed during two breeding seasons in California had the same members both seasons (Morrell, 1972). Egoscue (1962) recorded three examples of polygamy. In each case one female appeared to be younger than the other, and their litters were of different ages. Young-of-the-year foxes do not breed, and nonbreeding adults are invariably solitary (Morrell, 1972; Egoscue, 1975). Females may reach breeding age a year later than males (Egoscue, 1975).

Length of the gestation period is unknown, but is presumed to be similar to that of the red fox (given as 49 to 56 days by Cockrum, 1962). Litters are born in February or March; litter size is usually four or five, and the sex ratio is roughly even (Egoscue, 1956, 1962, 1975; Morrell, 1972). A neonate described by Egoscue (1966) was covered with soft hairs approximately 1 to 3 mm long, buffy to gray-brown in color, and thickest on the head, neck, and back. Mystacial vibrissae and toenails were present, but none of the teeth had erupted. Eyes and external ear openings were closed. Total length was 162 mm and weight was 39.9 g. By one month of age short, woolly puppy fur is present on pups, and guard hairs and dark pigmentation on the muzzle are already obvious. The eyes are gray-blue (Egoscue, 1956). Egoscue (1962) described postnatal cranial development.

Vixens rarely leave the den while suckling very young pups. The male seems to do most of the hunting during this period, although he may not live in the natal den. Later, both parents provide food until the pups start to forage with them at three to four months of age. Food is brought back to the den whole; there are no accounts of regurgitation. Adults may lose weight during June, July, and August when provisioning demands are heaviest (Egoscue, 1962).

Pups emerge from the den at about one month of age and spend several hours each day playing outside the entrance. Pups average 227 to 454 g per month weight gain and reach adult weight by late July or August (at about five months of age). Puppies develop the black tip on their tails and begin to acquire adult summer fur by four to five months of age (Morrell, 1972). Winter pelage develops in late summer, with most foxes having a full winter coat by the end of October. Egoscue (1962) was able to distinguish a light and dark color group in all age classes.

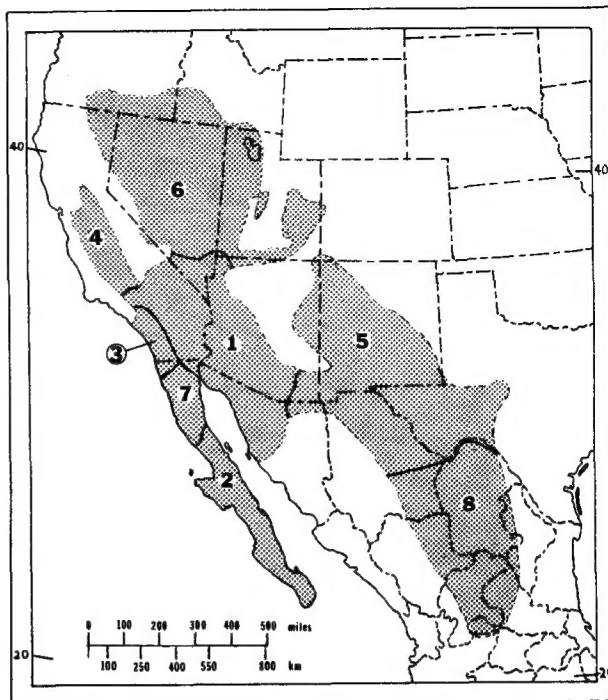


FIGURE 4. Historical distribution of *V. macrotis* and its subspecies (modified from Hall and Kelson, 1959). 1, *V. m. arsipus*; 2, *V. m. devia*; 3, *V. m. macrotis* (extinct); 4, *V. m. mutica*; 5, *V. m. neomexicana*; 6, *V. m. nevadensis*; 7, *V. m. tenuirostris*; 8, *V. m. zinseri*.

Family groups generally split up in October. A number of pups or a pup and one of its parents may stay together in the den after the family separates. Pups almost invariably disperse beyond their parents' home range, and solitary adults may occupy smaller dens after dispersal (Morrell, 1972; Egoscue, 1975). Kit foxes have lived 10 to 12 years in zoos (Mann, 1930; Crandall, 1964), but a seven year-old wild fox examined by Egoscue (1975) was very feeble and had worn and broken teeth.

ECOLOGY. Kit foxes are closely associated with steppe or desert climates. In most areas the native vegetation is shrubby or a shrub-grass combination: saltbush (*Atriplex polycarpa*) in central California; shadscale (*A. confertifolia*) and creosote bush (*Larrea divaricata*) in the Mohave Desert; shadscale, greasewood (*Sarcobatus vermiculatus*) and sage brush (*Artemisia tridentata*) in the Great Basin. About 75% of 92 kit fox sightings collected in a two-year study in Utah were in areas with less than 20% ground cover; light-colored, loamy desert soils; and elevation lower than 1,675 m (McGrew, 1977).

The primary item in the kit fox diet is usually the most abundant nocturnal rodent or lagomorph in the vicinity of the den. Benson (1938) remarked that in the eastern part of its range, the distribution of *V. macrotis* closely parallels that of the banner-tailed kangaroo rat (*Dipodomys spectabilis*). Grinnell *et al.* (1937) and Laughlin (1970) suggested that a dependency on kangaroo rats accounts for *V. macrotis* distribution in California. San Joaquin kit fox dens are most common in areas with high concentrations of kangaroo rat burrows (Laughlin, 1970); and Morrell (1972) observed nothing but kangaroo rats fed to *V. m. mutica* pups by their parents. Kangaroo rat remains occurred in over 80% of 52 *V. m. mutica* scats from Kern County, California, while rabbit remains (*Lepus*, *Sylvilagus*) occurred in 52% (Morrell, 1972). Eighty to 90% of approximately 600 scats collected throughout the range of *V. m. mutica* consisted of *Dipodomys* remains (Laughlin, 1970).

Egoscue (1962) found that *Dipodomys* spp., although among the most common rodents on his study area in western Utah, were utilized by kit foxes far less than reported by other studies. Careful examination of prey remains collected at a den during the puppy season showed that black-tailed jack rabbits (*Lepus californicus*) made up over 94% of the food eaten over a 64-day period by a family (two adults and five pups) of *V. m. nevadensis*.

A later investigation (Egoscue, 1975) followed kit fox population dynamics during a decline and initial recovery of *L. californicus* numbers in western Utah. The first response, occurring at least a year after the rabbit decline began, was the presence of resident nonbreeding vixens on the study area, the first such animals in 14 years of observations. During the second and third years of the study the proportion of nonbreeding adults continued to increase, while the total number of resident adults declined. The remaining foxes produced fewer and smaller litters than normal. As jack-rabbit numbers began to increase in the third and fourth years, the first sign of recovery in the kit fox population was a return to normal-sized litters. Kit foxes are opportunistic feeders to some extent, feeding on ground-nesting birds, reptiles, and even insects (Egoscue, 1962; Laughrin, 1970; Morrell, 1972). However, Egoscue (1975) found no evidence of switching to diurnal prey or of moving to areas of greater abundance of secondary prey when numbers of primary prey species declined.

The number of resident adults in any particular area seems to be fairly constant from year to year. New residents are recruited only as old animals leave or die (Morrell, 1972; Egoscue, 1962). Population density in optimum habitat in western Utah reached a maximum of about two adult foxes/259 ha (Egoscue, 1962). On an expanded study area, density ranged from one adult/471 ha to one adult/1,036 ha during a 3-year population decline (Egoscue, 1975). Morrell (1972) reported a stable density of six adults/259 ha on his study site in California. This may have been an atypical situation: Laughrin (1970) estimated average population density in the same general area at about one adult/259 ha. The total population of *V. m. mutica*, based on surveys of active dens, is estimated at about 10,000 adult foxes, with a mean density of about three adults/259 ha for the entire range (Morrell, 1975).

Kit fox dens usually have multiple entrances, the number ranging from two to as many as 24. All natal dens examined in Utah had three or more entrances (Egoscue, 1962). Entrances tend to be a little higher than wide and are usually too narrow for a coyote or badger. Tunnels in a den excavated by Morrell (1972) ran 3 to 6 m at depths reaching 127 cm. Dens are not scattered at random, but occur in groups. Dens in these preferred areas are numerous, and most are vacant at any given time. Vegetation is often greener around old, established dens, perhaps due to the accumulation of feces and prey remains in the tunnels (Egoscue, 1962). Vacant dens deteriorate rapidly, and are often occupied by burrowing owls (*Speotyto cunicularia*), antelope squirrels (*Ammospermophilus leucurus*), side-blotched lizards (*Uta stansburiana*), and various invertebrates (Egoscue, 1956). Several dens may be used during the year. Den changes are especially frequent during the summer when puppies are being fed. These moves may be related to a buildup of ectoparasites in the den or to depletion of prey in the area (Egoscue, 1962; Morrell, 1972). Dens being used by a family are not used by other foxes. However, "ownership" of these dens may change from year to year. In areas where dens were unavailable, kit foxes have been known to rear their young in culverts (Egoscue, 1956, 1962), pieces of oil well casing (Morrell, 1972), converted wood rat (*Neotoma* spp.) dens, and even a muskrat (*Ondatra zibethicus*) "house" on a migratory bird refuge (McGrew, 1977).

Details of kit fox movements are largely unknown. Nocturnal foraging trips are made in the vicinity of the den. Morrell (1972) stated that San Joaquin kit foxes apparently spend their entire lives in an area of 260 to 520 ha. Grinnell *et al.* (1937) gave 3.2 km as the maximum straight-line distance that foxes foraged from their dens in Death Valley. In Utah, foxes often covered several kilometers while systematically hunting for prey, but seldom got more than three km from the den (Egoscue, 1956, 1962). Home ranges overlap broadly, and foxes from different family groups hunt the same areas, although not at the same time, suggesting that no specific hunting territory is maintained or defended (Morrell, 1972).

The distance moved by dispersing pups after leaving the home area is unknown. Very few pups establish themselves as adults in the area where they were born (Egoscue, 1975). Foxes tagged as puppies have been recaptured as far as 32 km from their original point of capture, and one adult female kept as a pet was recaptured in her original den area approximately 32 km from where she escaped (Egoscue, 1956).

Very few accounts of predation on kit foxes by other animals are available. Seton (1925) suggested that yearlong denning is "... due to the necessity of a refuge from coyotes." Egoscue (1956, 1962) mentioned an account of coyotes digging at a kit fox den. Kit fox remains were found in only one of 1,088 coyote stom-

achs from New Mexico, and one of 569 stomachs from Texas (Sperry, 1941). No kit fox remains were reported in approximately 6,700 other coyote stomachs examined.

Kit foxes have been reported to host ticks, mites, chewing lice, and several species of fleas, of which *Pulex irritans* is the most common. Voge (1952) described a hitherto unknown cestode (*Mesogyna hepatica*) found in the liver of a kit fox collected in California. Other unidentified round worms and tapeworm proglottids have been observed in kit fox feces (Egoscue, 1956).

The effects of predator control on kit fox populations has been hotly debated. Egoscue (1956, 1962) noted that, contrary to most published accounts, kit foxes are not very wary of man, and many are killed each year by trapping, poisoning, and shooting. Numerous accounts (Grinnell *et al.*, 1937; Benson, 1938; Cahalane, 1947; Egoscue, 1956, 1962) comment on drastic reductions of kit fox populations due to early poisoning campaigns directed at wolves and coyotes. Even recent accounts (Schmidly, 1977) attribute kit fox scarcity to antipredator activities.

On the other hand, Robinson (1953, 1961) and Linhart and Robinson (1972) presented evidence that small, nontarget predators, including kit foxes, actually increased in numbers in areas of intensive coyote control with agent 1080. They attribute this increase to the widely scattered placement of 1080 bait stations which had relatively less effect on smaller predators than on coyotes. Cain *et al.* (1971) concluded that "... the evidence does not point to profound effects of predator control on nontarget species."

Jensen (1972) suggested that secondary poisoning due to indiscriminate use of toxicants for rodent control could be an important mortality factor for *V. m. mutica*. The oral LD 50 for 1080 is about 0.22 mg/kg for kit foxes, and a single rodent often consumes sufficient 1080 grain bait before dying to be lethal to a kit fox (Schitoskey, 1975). However, Swick (1973b) observed no poison-related kit fox mortality in a field test of aerially applied 1080 baits for ground squirrel control, even though kit foxes were observed hunting in the treated areas within hours of the application. Night hunting by varmint callers, road kills, and off-road vehicles are all significant sources of mortality for San Joaquin kit foxes (Laughrin, 1970; Jensen, 1972; Morrell, 1972). However, conversion of native habitat to agriculture and industrial uses has been the chief factor contributing to the decline of this subspecies (Laughrin, 1970; Jensen, 1972; Morrell, 1972, 1975). There was a 34% reduction in native vegetation within the range of *V. m. mutica* between 1959 and 1969 (Laughrin, 1970). Between 1968 and 1971 about 46,000 ha of natural vegetation were converted to irrigated cropland in Kern County alone (Jensen, 1972). It was largely due to this precipitous loss of habitat and the accompanying decline of the native fauna that *V. m. mutica* was included on the List of Endangered Species (Morrell, 1975).

The existence of kit foxes in association with irrigated cropland and urban development should probably be considered marginal (Morrell, 1975), although there are numerous accounts of foxes existing within city limits (Jensen, 1972), close to roads and occupied buildings (Egoscue, 1956, 1962), or in fields or levees adjacent to irrigated cropland (Swick, 1973a; Morrell, 1975). Ranchers are urged to leave an occasional island or knoll of native vegetation covering at least 16 ha to create feeding and habitat for remaining foxes (Allison, 1970).

California has a fairly comprehensive program for conservation and management of nongame wildlife, including kit foxes (Bury, 1975). *V. m. mutica* and *V. m. arsipus* have been listed by the state as protected furbearers since 1965, and *V. m. mutica* was declared a rare species under the California Endangered Species Act of 1970. Since 1965, surveys of active *V. m. mutica* dens have been conducted annually, at first by horseback and truck and more recently by low-flying aircraft and permanent spotlight transects (Morrell, 1975). These surveys (Laughrin, 1970; Jensen, 1972; Swick, 1973b; Waithman, 1974; Morrell, 1975) have determined areas of critical habitat, distribution limits, and estimates of adult population numbers. A large portion of the range of *V. m. mutica* has been closed to night hunting, and aerial application of 1080 rodent bait is now closely supervised. Public awareness of the beneficial aspects of kit foxes has been increased by educational programs.

BEHAVIOR. No detailed accounts of kit fox behavior exist in the literature. Reproductive, hunting, and denning behavior are summarized elsewhere in this account.

Kit foxes appear to use olfactory cues in much the same manner as do other canids. Urine and feces are placed around dens, along trails, and on or beside prey remains and other prom-

inent objects (Egoscue, 1962). One or more tunnels of a den may also be used as a latrine. Although these foxes have functional anal and supracaudal glands, there is no evidence of marking with glandular secretions.

Egoscue (1962) described several kit fox vocalizations. Females barked to recall straying puppies, and adults sometimes barked at humans approaching their den. Some foxes growled when handled, and a hacking growl was noted in intraspecific aggression. Captive foxes or foxes in their dens made a croaking noise with the mouth closed. Morrell (1972) also reported this vocalization and described it as resembling the sound of a perking coffee pot. A "lonesome call" was emitted by pups and adults separated from their cohorts (Egoscue, 1962).

GENETICS. According to Thornton and Creel (1975), *V. macrotis* has a diploid number of 50, including four pairs of large metacentric and 20 pairs of submetacentric chromosomes. There is a close similarity to the karyotype of *V. velox*. The microchromosomes predicted by Todd (1970) have yet to be confirmed in either *V. macrotis* or *V. velox*. The karyotype of a presumed *V. macrotis* × *V. vulpes* hybrid had a diploid number of 43 (*V. vulpes* has a 2N of from 35 to 39). It was possible to recognize 14 metacentrics (presumably nine from *V. vulpes* and five from *V. macrotis*) and 28 submetacentrics (eight from *V. vulpes* and 20 from *V. macrotis*), plus a single microchromosome from the red fox (Creel and Thornton, 1974).

REMARKS. Revision of the several subspecies of *V. macrotis* is long overdue. Waithman and Roest (1977) studied the five subspecies occurring in California and Baja California, and recommended that *V. m. arsipus*, *devia*, and *tenuirostris* be synonymized under *macrotis*, leaving *V. m. mutica* as a valid subspecies. This proposal is consistent with the morphology, distributions, and habitat preferences of the five forms, but it is based on very small sample sizes of *devia* (N = 6), *macrotis* (N = 5), and *tenuirostris* (N = 6). Also, the authors did not consider the question of the similarity between *V. m. arsipus* and *V. m. nevadensis* noted by Grinnell *et al.* (1937) and Hall (1946). Likewise, the sample of *arsipus* which they examined lacked specimens from eastern Arizona, so no comparison was possible with *V. m. neomexicana*. Final revision of the subspecies should be delayed until additional specimens can be collected and a detailed comparison of existing specimens of all eight subspecies can be made.

Numerous authors (Lechleitner, 1969; Bueler, 1973; Ewer, 1973) have treated *V. macrotis* as a subspecies of *V. velox*. Others (Hall and Kelson, 1959; Armstrong, 1972) mentioned the similarities between the two forms, but chose the conservative course of full specific status until intergradation could be established. Rohwer and Kilgore (1973) compared skulls from the region of potential contact between the two species in west Texas and eastern New Mexico with *V. macrotis* and *V. velox* reference materials. Discriminant analysis revealed that, while phenetic intermediates were concentrated along the interface between the two forms, "typical" parental-type specimens were also found in the area of contact, and moderately intermediate forms were found far from the interface. The interface itself was quite narrow, and no evidence of hybridization beyond about 50 km on either side of the line was observed. The line appeared to be stable historically, and the authors concluded that selection generally opposed hybrids and favored maintenance of separate adaptive forms.

Thornton and Creel (1975) described a number of external characteristics (length and set of ears, shape of head, length of tail—see Diagnosis above) which consistently allowed separation of specimens. Preliminary electrophoretograms of serum proteins and hemoglobin from *V. macrotis* and *V. velox* also seemed to show recognizable differences.

Rohwer and Kilgore (1973) pointed out that the interface between the two foxes closely corresponds with the interface between the desert and high plains grasslands. Since *V. macrotis* and *V. velox* are so similar in size and food habits, it is unlikely that they could coexist with overlapping home ranges in areas of sympatry. Although the nature of the competitive superiority of each form in its own habitat is unknown, it is probably this superiority which limits intergradation and accounts for the stability of the interface (Rohwer and Kilgore, 1973).

The generic name *Vulpes* comes directly from the Latin *vulpes*, meaning "fox." The specific epithet, *macrotis*, originates from the Greek roots *makros*, meaning "long" or "large," and *otos* (genitive of *ous*), referring to the ear.

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